Weather and climate knowledge for water security: Institutional roles and relationships in Turkana

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Working Paper

Weather and climate knowledge for water security: Institutional roles and relationships in Turkana

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Abstract

Lodwar town in Turkana County faces water security issues relating to its strategic location, (semi-)arid climate, hydroclimatic variability, high poverty rates, low piped water service and a rapidly growing population – challenges that are also relevant to many Kenyan and African small towns in fragile environments. Political, economic and environmental changes affecting Lodwar, including devolution, climate variation and change, demographic shifts, and the exploration of subterranean resources (both water and oil), make this an important time to examine the challenges and prospects for inclusive water security. This working paper discusses findings from a 2016 study of the institutions involved in water decision-making in Lodwar, focusing on their access to and use (or non-use) of weather and climate information. What organisations are involved in water decisions affecting Lodwar town; how do they negotiate information access, accountability and uncertainty; and what is at stake? Drawing on qualitative material collected during a 10-week study of institutional arrangements and decision-making, this paper explores connections and mismatches between weather/climate knowledge and water decisions in Lodwar town and the wider Turkwel basin.

1. Introduction

This case study is situated within the REACH programme's Turkana observatory 'small towns in fragile environments', which focuses on understanding water security in Lodwar town, Turkana County's headquarters. As a growing urban centre in a strategic location, with high rates of poverty and low service of piped water supply, Lodwar exemplifies many of the water security issues faced by small towns in fragile environments across Kenya and Africa. A key question for the observatory, set by the REACH programme, is: 'what are the institutional responses and risks for small towns to address converging issues of resource variability, demographic growth, infrastructure fragility and financial sustainability to ensure inclusive water services for all?' This social-scientific study, based on research undertaken in Kenya in 2016, links work on hydroclimatic risks with work on building institutions and risk decision-making, by exploring connections and mismatches among organisations, information and decisions, and thus contributing to better understanding of the opportunities and challenges for institutional co-ordination in a context of hydroclimatic variability, climate shocks, political decentralisation, and competing priorities for water use.

1.1. Context: Lodwar as a small town in a fragile environment

Situated in north-western Kenya, Turkana County comprises arid to semi-arid lands, in common with 80% of Kenya's land area. Its landscape of plains and isolated mountains is generally hot and dry year-round: the long rains are in principle expected from March to May and the short rains from October to December (although they are unreliable). Figure 1 shows rainfall climatology for Lodwar. Climatological analysis indicates increasing frequency of severe droughts (Opiyo et al 2015). When the rains do come, or when they fall upstream in the Turkwel basin, the numerous dry river beds (locally known as *lagas*) which pattern the plains fill quickly and dangerous flash flooding can occur, as happened during the long rains in early 2016. Most of the rivers are seasonal, including the Kawalase, which skirts the north of Lodwar town. The most notable exception is the Turkwel River, which rises in Mount Elgon and flows through Lodwar and eventually into Lake Turkana. The river is now ostensibly perennial, following construction of a hydroelectric dam upstream from Lodwar at Turkwel Gorge in the late 1980s.

According to national statistics, Turkana County

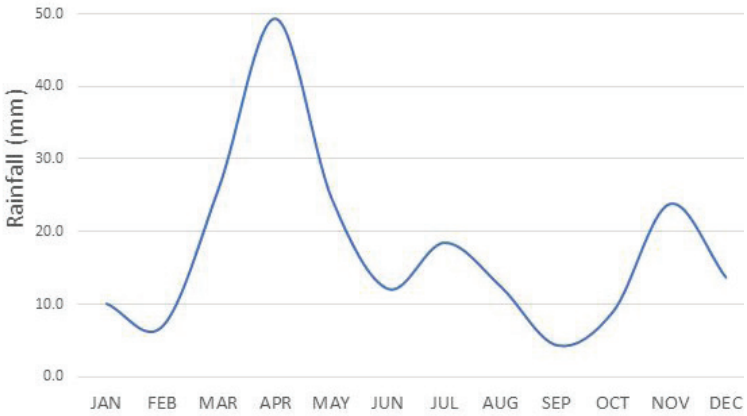

Figure 1: 1950-2009 rainfall climatology for Lodwar (data source: KMD[2])

has the highest proportion of people living below the national poverty line in Kenya, at 87.5% (KNBS & SID 2013). Pastoral livelihoods are the dominant economic activity for the county: many Turkana people undertake nomadic animal husbandry, raising cattle, goats, sheep, and camels. At time of research, no cattle were visible in the area around Lodwar. According to local residents they had already been moved towards border areas and highlands where pasture was available. While this study focuses on the urban 'small town' setting, it is important to recognise that the demographic and economic configurations of the town are greatly influenced by the movement and conditions of rural pastoralist livelihoods across this part of Kenya and the wider region.

There is a significant body of literature examining the suitability of pastoralist mobility as an adaptation to arid and semi-arid environments, where the distribution of rains in time and space is uneven (e.g. Catley et al 2013; Hogg 1987, Leslie & Little 1999, McCabe 1990). In the contemporary setting, this mobility is also tied to conditions surrounding the existence and location of a wide range of administrative, physical, community, and national boundaries. Several factors are driving shifts in livelihood patterns, including the following: changes to communal land tenure related to urban growth, agricultural developments and extractive industries (i.e. an increase in individual land ownership leading to fencing); development interventions to settle mobile populations; famine relief programmes; internal and cross-border insecurities; and resettlement programmes, both of international refugees from South Sudan, Ethiopia, Rwanda, Burundi, Somalia, Uganda and DRC (in the Kakuma camp in Turkana West) and 'internally displaced persons' (IDP), who were settled on the outskirts of Lodwar following post-election violence in 2007-8.[3] Shifts from mobile pastoralist to (semi-)settled livelihoods are associated with changes in the resource interactions and demands of the population. As Eriksen and Lind (2009) note, destitute populations in towns and peri-urban areas - including in resettlement areas – are particularly vulnerable to shocks such as drought and conflict.

On the surface, the terrain of Turkana County appears stark. Nonetheless the last few years have seen heightened anticipation around subterranean resources, both oil and groundwater. Oil exploration has recently focused around Lokichar and Kapese, and an Early Oil Pilot Scheme is scheduled to start in 2017. At the time of research, stakeholders were awaiting final decisions concerning the source of the water that is needed for production (to replace oil in reservoirs and to supply the camps), and the infrastructure that will facilitate movement of the crude oil from Turkana to Mombasa. With respect to the latter, the current road infrastructure linking Lodwar to centres further south is very poor quality and there are ongoing security concerns about road travel in this area (in the words of one research participant: 'we say we don't have a road'). The discovery of oil in Turkana also brought a new dimension to the proposed LAPSSET (Lamu Port-South Sudan-Ethiopia-Transport) infrastructure project which had been set to open up a major pipeline and transportation corridor linking Kenya's ports to South Sudan and Ethiopia through Turkana, though the project currently appears to be on hold[4]. In 2013, the report of a survey commissioned by UNESCO and carried out by Radar Technologies International (RTI) raised expectations of large reserves of groundwater in aquifers beneath Turkana (Gachet 2013a), though further research and validation have not yet been forthcoming (cf. Avery 2014). As well as these potential subterranean resources, more visible surface-level developments related to energy are emerging across the county's plains, for example wind farms and solar arrays, as well as new irrigation initiatives.

The promise and anticipation of extractive industries and transportation infrastructures have material, social and emotional implications, even when plans are uncertain or stalled (Haines 2017, Weszkalnys 2014). These effects can be particularly potent in places where a significant aspect of local identity is bound up with the perception and experience of being marginalised from political and economic centres. People in Lodwar continue to describe travelling to other parts of the country as 'going to Kenya', although devolution has brought more visibility to government in Lodwar at least (notwithstanding that the county government is controlled by the national opposition party, a situation which brings its own tensions to debates over credit and responsibility for road improvement projects and oil revenue agreements). This research was undertaken in late 2016; with elections looming in August 2017 it seemed reasonable to expect further institutional shifts to accompany the

intensification of both political manoeuvring and the emerging drought situation.

1.2. Scope and methods

The case study addressed the following research questions: What institutions are involved in water decisions affecting Lodwar? How do they negotiate information access, uncertainty, and accountability, and what is at stake? It contributes to the wider REACH programme by eliciting the needs and constraints of water decision-makers and by unpacking the assumption that providing more weather/climate information will automatically lead to better decisions (see e.g. Cash et al. 2006).

This working paper draws on research undertaken in Kenya from October to December 2016. The focus was on Lodwar town, and in particular the ostensibly 'formal' institutions (for example government agencies and non-governmental organisations) with mandates and goals involving the water sector. Nonetheless, in the course of the research it became clear that the definition of the 'town' is not necessarily fixed or stable, and the distinction between 'formal' and 'informal' institutions is not always clear. Given the scope of this study it was not possible to examine in detail the roles and responsibilities of some of the more embedded social networks and customary institutions involved with socio-ecological decision-making. However, successful communication and implementation of further research and action will require recognition of and respect for trusted existing structures and networks, and acknowledgement of the interdependence of urban, peri-urban and rural conditions across the county. This study complements ongoing work in the Turkana observatory being led by the REACH team at the University of Nairobi, including a water services/infrastructure audit conducted in June 2017, and socio-economic research into the linkages between poverty and water (in)security.

The methodology centred on semi-structured qualitative interviews (Bernard 2006) with water and weather/climate sector professionals. The interviews were designed and carried out with the intention of exploring key topics from the perspective of the participant, and thus gaining insights into the meanings that knowledge practices and decision-making processes hold for them. Where possible, interviews were conducted at the participant's place of work, to provide opportunities for gathering additional observational data about the professional contexts in which interviewees operate. The interviews took the form of conversations guided by a protocol covering core themes: background of the organisation and respondent; how decisions are made within the organisation; measures of success; sensitivities to weather and climate; accessing information; using weather and climate forecasts; and planning for the future. Each interview lasted approximately one hour. Eleven interviews were conducted in Nairobi with representatives of national-level institutions, and 33 were conducted in Lodwar with local officials and organisations. Three additional interviews were conducted in Eldoret and Turkwel with Kerio Valley Development Authority (KVDA) and KenGen staff involved with managing the Turkwel Gorge hydroelectric dam and the broader multipurpose development project of which it is part. The interviews were supplemented by participant observation at relevant meetings and workshops, a site visit to the Turkwel Gorge dam, and situated observations in and around Lodwar town including guided walks and drives and informal discussions.

1.3. Theoretical framework: information and decisions

This paper builds on a growing body of social science literature on the use and non-use of information for decision-making. In particular, it is informed by studies that address the institutional as well as technical factors that influence the usability of uncertain weather/climate forecasts for operational and policy decisions in the water sector. Rayner et al.'s (2005) study of US water managers demonstrated that despite improvements in forecasting skill associated with increasing understanding of the El Niño Southern Oscillation, water managers in different sites in the US were reluctant to use the forecasts to make operational decisions. Analysis of ethnographic interviews revealed that this was not only due to the characteristics of the forecast (reliability, spatial and temporal scales) but also an organisational 'culture of invisibility' in which innovation was not incentivised, and large infrastructure was the preferred way to deal with supply risk. There was also a strong emphasis on local knowledge and craft skills among the decision-makers.

Since the 1990s, social scientists and policy workers have developed concepts and practices of 'co-production' which (in one definition) aim to bring together diverse stakeholders to generate knowledge that is more salient, credible and legitimate to its intended users (Cash et al. 2006, Meadow et al. 2015). Examples of such mechanisms include 'boundary organisations', introduced to mediate the interface of science and policy, such as the US Regional Integrated Sciences and Assessments programme (Lemos et al 2014, Kirchhoff et al 2013) and the Regional Climate Outlook Forums (Cash et al. 2006). With growing attention to 'climate services' and a push to 'downscale' global climate models to produce more localised seasonal forecasts, practical and conceptual challenges have emerged in connecting user needs and societal impacts with the provision of scientific information (Broad et al 2007; Dilling & Lemos 2011; Patt & Gwata 2002; Vogel and O'Brien 2006). This study draws on these observations to explore the social dimensions influencing – and potentially informing - the use and usability of weather and climate information with respect to water security in Lodwar.

2. Emerging Themes

The rest of this working paper expands on five key themes emerging from the analysis. The first two (*locating the small town* and *water services governance*) provide context for the study of institutions and information in this observatory. The other three (*flows and non-flows*, *use and non-use of weather/ climate information*, and *negotiating diverse knowledges*) directly address the research questions. The paper concludes with a discussion of the key findings and their implications.

2.1 Locating the small town: expansion, infrastructure and the margins

An early challenge for translating the observatory aims and research question has been the fluidity of the 'small town' definition. The administrative location of Lodwar Township encompasses three sublocations: Lodwar Town (where the central business district is located), Nakwamekwi, and Napetet. Kanamkemer – a growing area south of the Turkwel River - is a separate location comprising Kanamkemer and Nawaitorong sublocations, though in conversation it is frequently considered part of Lodwar. The presence and expansion of peri-urban villages, estates and IDP resettlement areas in these sublocations on the margins of central Lodwar mean that the boundaries of the town are not always well-defined or agreed. For example, the definitions of IDP resettlement areas can be particularly sensitive, and the population of peri-urban areas can shift seasonally or in response to other conditions that affect the livelihoods of the region's pastoralists. For the purposes of this case study, however, it was not necessary to map out strict boundaries: research participants' definitions and descriptions were instructive in building a picture of the town and the different shapes it can take.

Documents and interview participants offered various estimates of the population of Lodwar. The 2009 census reported the town's 'core-urban' population to be 45,368, with an additional 2,948 'peri-urban' residents and 9,902 in surrounding rural areas (KNBS 2010). The projected population for Lodwar in 2017 is 75,726 (224,792 for the constituency of Turkana Central), according to the County Integrated Development Plan (CIDP) (Turkana County Government 2014) and 2015/16 Annual Development Plan (Turkana County Government 2015); while estimates among participants ranged from 60,000 to 150,000. Many conversations touched on Lodwar as a growing and 'cosmopolitan' centre, owing to the numerous and diverse people who had been recently attracted from other parts of the country, primarily by the promise of job opportunities relating to devolution and oil exploration. The history of in-migration to the town did not start with devolution: many people moved to Lodwar fleeing post-election violence in 2008, or seeking relief during the famines of the 1970s and 1980s. However, it is broadly acknowledged that many of these would have been Turkana people coming from the surrounding rural areas or returning to their family homes from different parts of the country. Devolution and oil are seen to be attracting a broader range of people from many different places and backgrounds.

As the town expands, some of the peri-urban villages/estates are starting to join with the urban centre, physically filling interstices with residential and business buildings, and also becoming infrastructurally joined, via connections to utilities such as water and electricity. Lodwar's fluctuating

boundaries and the incorporation of informal and designated resettlement areas pose challenges for planners and utility suppliers, who explained that they often feel they are working in reactive mode, having to 'catch-up' with increasing demand as the town's shape and density shifts.

2.2 Water services governance: pipes and power

A wide range of institutions have stakes and roles in water governance and information provision for Lodwar. At national level, relevant ministries, agencies and parastatals include the Ministry for Water and Irrigation (MWI), the Water Resources Management Authority (WRMA), the Water Services Regulatory Board (WASREB), the Kenya Meteorological Department (KMD), the National Drought Management Authority (NDMA), and the National Environmental Management Authority (NEMA). Relevant ministries of the Turkana County Government include: Water, Irrigation and Agriculture; Public Service, Devolved Administration and Disaster Management; Pastoral Economy and Fisheries; and Energy, Environment and Natural Resources. Companies such as utilities providers, oil producers and hardware manufacturers also have stakes, as do UN organisations, NGOs, CBOs, international agencies and faith groups with operations in the area, including: UNICEF; UN WOMEN; GIZ; Oxfam; Practical Action; World Vision; Friends of Lake Turkana; the Catholic Diocese of Lodwar, and many more. As mentioned above, communities and customary institutions are also crucial, though they are largely beyond the scope of this case study.

Different actors and agencies have different perspectives and priorities when it comes to water. The County Ministry for Water, Irrigation and Agriculture (MWIA) is responsible for overseeing water as a provision for direct human needs and consumption; meanwhile the Ministry of Energy, Environment and Natural Resources pushes for budgetary resources in alignment with its understanding of water as an environmental resource, emphasising the need for 'water for trees' (with indirect benefits for humans and other animals); the Ministry for Pastoral Economy and Fisheries focuses foremost on the water requirements of non-human animals. There are also balances to be struck between national and county levels of governance. One senior officer at the county MWIA described management as a challenge, because 45% of water functions are still with the national government. Some organisations, such as the sub-regional branch of the Water Resources Management Authority, have a key role in trying to align local activities with national policy. This is an ongoing project for the county government as its water legislation must be checked to ensure correspondence with the recently published National Water Act of 2016[5].

For government and NGO staff, core water-related concerns – the ones that keep them awake at night - include: water quality; vandalism and maintenance of infrastructure/technology; drought/unpredictable rains; dependency on relief provisions; and weak governance (corruption was an underlying theme of many informal discussions). Many participants drew connections between water scarcity and 'insecurity' (specifically with reference to livestock raiding and related conflicts)[6]. County government officials highlighted drought as a key challenge, noting that seasonal calendars were no longer helpful owing to unpredictable rains, though they also implied that, with drought starting to make news headlines in late 2016, it might be a good time to mobilise support for restarting monitoring programmes, for example. In general, however, keeping one's head beneath the parapet was a favoured strategy: in line with Rayner et al.'s (2005) findings in the US, one official characterised 'success' for his role as keeping his officers satisfied and public outcry to a minimum. County officers noted the difficulty of trying to get a holistic picture of water projects given the history and current proliferation of non-governmental actors in the sector, suggesting a tension over ownership. Indeed, MWIA representatives expressed an as-yet unfulfilled desire to formalise ownership of assets and knowledge of all projects (governmental and non-governmental) through a single technical committee with regulatory powers.

Lodwar's main water services provider is LOWASCO (Lodwar Water and Sewerage Company), which reports to the County Ministry of Water, Irrigation and Agriculture. The Lodwar utility is ranked 56th of 84 publicly-owned water utilities by the Water Services Regulatory Board in its national benchmarking report for 2014-15 (WASREB 2016). Lodwar is ranked in the bottom 10 performers for 4 of 9 key indicators: drinking water quality; non-revenue water; water coverage; and metering

ratio. LOWASCO obtains water from 10 functioning boreholes near to the Turkwel River, from which water is pumped using electricity supplied by Kenya Power (LOWASCO representatives explained that they also have solar-powered pumps as back-up, but they are less powerful). The pumped water is stored in raised tanks around the town, for distribution by gravity through piped systems. According to LOWASCO representatives, the number of connections at the time of research stood at just under 7000, covering 50-60% of the population; they reported that even when all pumps are functioning, demand outstrips supply by about 100,000 cubic metres per month. About 40% of the town population is not covered by LOWASCO service. Areas that are covered experience scheduled rationing as well as unplanned interruptions, with rationing decisions based on population numbers and also the location of public services and government offices.

While rationing continues in areas already covered, the company is involved in projects working to spatially expand service to different parts of the town and surrounding areas – including some IDP resettlement areas, for example Kanaan (in Kanamkemer). During a visit to this area, residents pointed out the current extent of the pipes (residential lots in the northern section have access to taps while those to the south do not). The streets were busy with people carrying or rolling jerry cans, and there were queues at the taps, where people from the non-served areas came to purchase water from their neighbours. In the southern section, beyond the piped supply, is a boarded-up Oxfam water kiosk, dated 2009. A female resident explained that it had long been out of service; she purchased her water from the chief's house in the north section, sending her children with jerry cans to collect it. In other peri-urban areas including Nakwamekwi and Napetet there is limited piped supply and people tend to share water supply with neighbours, sometimes for a price. Hand pumps or solar pumps offered alternative water points (i.e. those not part of the LOWASCO piped municipal supply) in these neighbourhoods. These pumps had for the most part been installed and/or repaired by the Catholic Church, the county government, other NGOs, or the Turkana Rehabilitation Project (TRP); some were public and others operated as group or co-operative ventures; water was available free of charge at some and for a price at others. At a school borehole in Kanamkemer, staff explained that the water drawn from their solar pump was intended for the sole use of the school, but when the piped supply failed and they saw community members collecting water from the nearby river, they allowed people to collect water from the pump for their own use.

At the time of the study, documented details of the supply and distribution of water to the town were limited. However, the Kenya REACH programme has since conducted a water audit (in June 2017) to address this gap. As shown in Figure 2, the water audit also indicated that the Nakwamekwi area suffers from severe water shortages partly due to inadequate yields from boreholes (Dulo et al. 2017).

Problems with public water services were impossible to ignore during the research period in Lodwar. The town piped water supply was interrupted for a week in late October, and local people's reactions

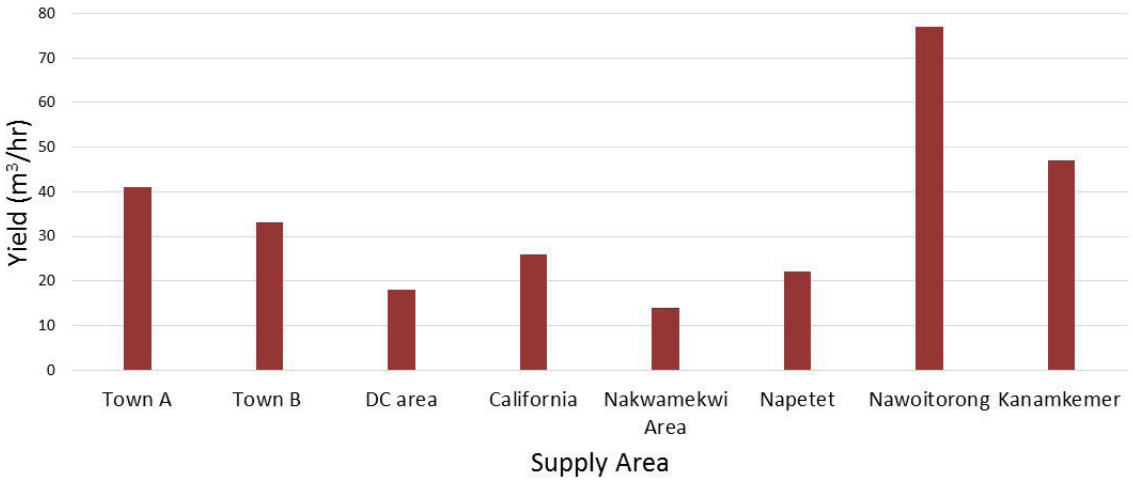

Figure 2: Amount of water supplied within selected supply areas in Lodwar. Source: Dulo et al. 2017

made it clear this had happened several times in recent memory. During the interruption, the number of people transporting yellow jerry cans (by foot, or precariously mounted on motorbikes and other vehicles) visibly increased; people could be seen at all hours of the day collecting river water from the Turkwel or queuing at alternative water points including privately-operated bowsers, as well as neighbourhood solar, wind and handpumps. Observations and conversations at town water pumps indicated that the (un)reliability of the municipal piped water supply is a crucial factor in availability, demand and pricing at these other water points in Lodwar and particularly the villages and estates on the margins. At some of these alternative sources, prices per 20-litre jerry can were reportedly hiked during the interruption from a base rate of 5-10 shillings to more than 50 shillings, and people had to queue for hours. When the piped supply failed, not only the residents of the peri-urban areas turned to the local pumps; people from the centre of town also came out to access water. During this time, at least, the infrastructural and governance challenges of water supply appeared more decisive than weather/climate factors in influencing the availability and accessibility of water. Given the dependence on groundwater supply, it is likely that these infrastructural and governance factors will always dominate. However, this groundwater is currently almost fully dependent on the Turkwel River, which itself relies on weather/climate of an area far removed from the town, as well as on dam operations. Thus, the weather/climate factors that influence availability and accessibility of water in Lodwar are often those experienced far upstream.

A definitive explanation for the October supply failure remained elusive, though interviewees, residents, and others who responded to the situation on social media sites such as Twitter mostly agreed that it was due not to a lack of water per se, but an infrastructural and governance problem. As reported by interviewees and in local and national media, LOWASCO had been experiencing management problems and conflicts with the county government for some time, with the former managing director having been in and out of court for his MD position. A technical lead had been seconded from the county government, but there was ongoing uncertainty about the company's management. Some blamed the failed supply on what they referred to as this 'transition problem' – more specifically saying that frozen accounts associated with the legal cases meant that LOWASCO had not paid its electricity bills to Kenya Power, and had thus lost the capacity to pump water from the boreholes. Different interlocutors attributed blame to different actors in this predicament: some blamed LOWASCO for mismanagement; others disdained the county government for not stepping in before the situation deteriorated; some challenged Kenya Power's decision to cut the supply given the implications. Others did not mention the billing issue, but blamed the unreliable electricity supply. Some suspected foul play, given that the interruptions provided business opportunities for water trucking companies. While inconclusive, these different narratives of blame provide insights into the politicized tensions among key organisations about their mandates and responsibilities for water provision, and characterise key themes of infrastructural failings and political corruption.

2.3. Flows and non-flows: data and institutional flux

Interview participants from a variety of institutions, including WRMA, MWIA and the local KMD station identified instrumentation and data gaps as a problem for water management. One repeated concern was the need to improve hydrological data on river flows between the Turkwel Gorge dam and Lodwar (and subsequently Lake Turkana), given a perceived lack of clarity about abstractions along the river, for example for irrigation. Another concern was with obtaining reliable meteorological observations to tailor weather forecasts to local areas. KMD officers named 6 automatic weather stations across the county, but noted that of about 50 manual gauges only 10 were currently operational. As noted above, it is also the case that relevant weather and climate information needs to be sourced from an area much wider than Turkana County. KMD officers described three main obstacles to effective data collection: the geographical extent of the county; the political insecurities (for example conflicts at the Turkana/West Pokot border near to the Turkwel Gorge); and the mobility and illiteracy of the rural population:

> Turkana County is 77,000 square kilometres… And when you try to look where we have placed all those instruments, they are very far away from each other. So it means the data which has been collected is not enough to capture

> the whole county... There are some areas that you cannot access, because of the insecurity problem. Here in Turkana County, insecurity is very bad. And those areas you cannot go and - for example - install a rain gauge there. Because you might be attacked... People in Turkana County, they are pastoralist. So they move from one place to another. For example, if you put a rain gauge here today, tomorrow you find those people have already moved. So there is nobody who is going to collect the data... And another thing that we normally face here is the illiteracy level is so high; maybe for example you are sending somebody to go and then collect that kind of data and it is not 100% correct -- whether he has put the correct information on the form that you have given him or her.

While satellites were acknowledged as useful for obtaining measurements of vegetation and lake levels, some respondents described this data as less helpful for providing accurate rainfall measurements, as rain picked up in satellite images may evaporate before it reaches the ground.[7] Reasons given for data limitations included lack of functioning instruments, for example the KMD rain gauges mentioned above, and the staff gauges mounted on the bridge piers in the town, which one participant noted were frequently out of the water and thus not able to accurately measure low flows. Respondents involved in infrastructure development described their biggest 'nightmare' to be making high-stakes decisions based on 'bogus' data.

While these concerns refer to the problem that important and good quality datasets may not exist, interviewees also lamented a lack of access to data that did exist. Some noted that public agencies have a duty to disseminate data, as Kenyans have a constitutional right to information as guaranteed by the Access to Information Act of 2016 which seeks to create a framework to facilitate access to information held by private bodies and promote routine and systematic information disclosure by both public service and private service.[8]

Several factors were seen to inhibit data sharing. As well as noting problems associated with the cost and contractual negotiations of accessing some international/satellite data, interviewees described how data could also be valuable political resources that could be withheld or exchanged in political transactions, particularly with national elections on the horizon. One county official said that the current priority was on 'firefighting' and stabilising the government, and that a lot of plans had been at least temporarily shelved; an agency worker said it was hard to get funding for projects and events that did not involve 'eating' (i.e. corruption). The project-based character of many development activities funded by non-government donors meant that relevant data could be lost to the archives of external organisations. Some noted the competition between different NGOs/CBOs working in the same domain, and said this led to organisations being 'selfish' with data, and increased the risk of wasted efforts. They criticised the pressures of budgetary and political cycles for promoting hasty implementations that could miss the lessons of previous work and lead to wasteful duplication (for example drilling a borehole in the same place as a previous failed borehole, or drilling in the wrong time or place and ending up with a saline supply which people will not use for drinking):

> The percentage of boreholes in this county that are saline vis á vis usable... you get very high percentages in saline. So you get unused boreholes that have been done by institutions. Communities wanted them, they need a borehole, [but] they can't use it, no-one is using it and everyone is wondering why.[9]

Communication to downstream stakeholders about upstream conditions was reported to be limited for the Turkwel and Omo Rivers, both of which flow into Lake Turkana. The hydropower dam at Turkwel Gorge regulates the flow of the Turkwel River, and this was generally welcomed because the flow is now perennial and flooding on this river has been mitigated. It was also noted that the design stages and operations of the dam had produced a lot of data about the upper reaches of the river. However, uncertainty remained about what happens to the water along the course of the river; local residents and officials in Lodwar also complained that at times the river had unexpectedly run dry for several days, when the dam's turbines were stopped but the lower-level release apparently was not activated and Lodwar authorities were not informed.[10] Several participants observed that Turkwel River water is abstracted for irrigation between the dam and Lodwar, although this is not regulated or monitored. Interviewees in environmental and fisheries sectors

noted additional physical and political uncertainties (with socio-economic consequences), given the development of the Gibe dams and irrigation projects along the Omo River in Ethiopia, which provides 90% of the water in Lake Turkana (Avery 2012).

Other potentially significant developments for Turkana County are also characterised by great uncertainty. The Lotikipi aquifer described in the 2013 UNESCO report (Gachet 2013a), surveyed by French firm RTI using novel imaging technologies, has been hailed by some as a miracle for Turkana and the answer to its water insecurity for many years to come. For others, the aquifer is at least partially a myth, unlikely to fulfil its promise and liable to create misleading expectations. Some interviewees criticized the report, describing its proprietary methods as a 'complete black box,'[11] and expressing frustration with the lack of peer review and verification. The idea of the underground lake has nonetheless travelled widely through documents, media reports, and oral narratives. While the details remain ambiguous, and follow-up studies are awaited, the idea of the aquifer is a potent political object, and the topic of ongoing debate between national and local government. One county official complained that the national government was, in his view, encouraging perceptions of Turkana as a rich county: a characterisation that could have implications for future resource allocations.

As an ostensibly remote and historically marginalised area of Kenya, Turkana's public services had long been the preserve of what could be characterised as a 'surrogate' state (Jennings 2008) – with basic public services being undertaken by NGOs and in particular by the Catholic Diocese of Lodwar. In the words of one interviewee: before devolution, the Diocese 'used to be the government.' Devolution has catalysed a shift of responsibility for many public services to the county government, but the process of transferring mandates and functions is complex and incomplete. Decades of disparate project-based work mean that understanding the historical and contemporary landscape of service provision, knowledge and infrastructure is incredibly challenging. Many interviewees vocalised concerns that NGO and church interventions have fostered dependency among the local population; one county official said that this made it hard for the government to ask people to pay for water services.

Responsibilities for water are not fully devolved to county level (some functions remain with national agencies), and many relevant institutions are still in transition. A new National Water Act was passed during the fieldwork period in 2016, and – as noted above - will have implications for county water policies and legislation processes which are ongoing at the time of writing. Emerging organisations such as WRUAs (water resources users' associations) were elusive. Perhaps a symptom of this transitional period, several key organisations or agencies were being led by interim directors, or undergoing other personnel changes. Interviewees attributed high staff turnover at NGOs to the harsh environment and isolation of being posted in Turkana. This 'institutional flux' is likely to have implications for institutional memory and situated knowledge, and for ownership and exchange of ideas, data, and assets.

These challenges have not gone unnoticed by those involved in such transitions. Governmental and non-governmental actors are engaging in efforts with explicit co-ordination goals, for example through documents such as the CIDP, and a County Steering Group (CSG) that meets once a month and provides a forum for stakeholders to discuss emerging issues. The CSG is jointly chaired by representatives of county and national government, and the local NDMA is the secretariat. Underneath this layer is a technical sub-committee called WESCOORD (water and environmental sanitation co-ordination group), in which UNICEF has a key role (they also support similar initiatives at national level). While interviewees who were knowledgeable about these committees acknowledged their convening power and the benefits of bringing together relevant experts, many complained that the technical groups in particular would remain 'toothless' without regulatory powers and a requirement for organisations operating in these domains to declare their projects and share data. County government representatives appeared keen to use the groups to position the county government as the co-ordinating authority for project work undertaken in Turkana. In line with the shifting institutional landscape post-devolution, NGOs and agencies such as Oxfam, GIZ and others explained that they are changing their approaches: moving away from direct project implementation towards influencing government decisions and working in consortia to pool skills and resources. The 'mud map' diagram in Appendix 1

illustrates the complexity of the water sector in this observatory, showing the range of governmental, civil society and community organisations involved, and some of the key reporting lines, information flows, theme areas of interest and forums where different stakeholders are brought together.

2.4. Use and non-use of weather and climate information

Drought is a key feature of the literature on Turkana (e.g. Eriksen & Lind 2009; Hogg 1987; Opiyo et al 2015), and interviewees identified it as an important climate- and water-related risk. One of the core agencies involved in the County Steering Group and WESCOORD is the local NDMA, further emphasising the priority of drought in co-ordination and horizon-scanning activities. Nonetheless, widely agreed definitions of drought and its relevant metrics were not easy to pin down. Some interviewees commented that standard metrics were not useful, given the mobility of pastoralist populations across the region. Respondents noted that observations and forecasts of rainfall distribution, duration and intensity were insufficient across Turkana and surrounding areas; and that more information from upstream areas and border areas could be helpful in understanding the physical and political drivers and impacts of resource scarcity. Temperature as well as rainfall was recognised as important, owing to its influence on rates of evaporation. Ongoing uncertainty about the existence, status and recharge mechanisms of the Turkana aquifers was compounded by frustration that surveys for borehole locations were not being done and recorded with the necessary care (if at all).[12]

The NDMA drought early warning system uses multidimensional and impact-based indicators, looking beyond measures of rainfall to assess the impacts and status of drought. For the NDMA (and the agencies and organisations with whom it collaborates), differentiating 'stages' of drought – in terms of both progression over time and severity - involves setting and measuring against thresholds that distinguish between levels of 'alert', 'alarm' and 'emergency'. The identification and declaration of 'emergency' is a political and performative intervention; that is, it raises questions of who has the authority to decide whether or not an emergency has been reached (what indicators and impacts are seen to matter?), and what is made possible by declaring an exceptional situation. One NDMA employee described the challenges of aligning institutional and public notions of emergency vis á vis normality:

> Sometimes communication is hard, people say: 'we are already in an emergency!' But the NDMA have to look at a long period... There are different normals – we have to look at deviations from the long term.

In arid and semi-arid areas like Turkana, where rainfall values are very low with 'normals' of close to zero, it can be particularly challenging to determine meaningful thresholds based on these observations; declaring 'drought' in such situations becomes very difficult. The drought of concern may well be that which is experienced much further afield, in regions near the headwaters of the Turkwel River. Several respondents stated that rainfall could in fact cause more acute and severe problems than dry spells, because the quick onset of flash flooding and the relative rareness of such events mean that the population and authorities are less equipped to deal with the impacts.

In Lodwar, organisations and individuals were aware of the type and availability of information from the KMD (i.e. seasonal, monthly, 7-day and 5-day forecasts). Since devolution, Turkana has a County Meteorological Director, who heads a small team at the long-standing Lodwar synoptic station. Among research participants, there were variations in the levels of trust and credibility afforded to KMD forecasts by potential users. For some, having access to data legitimised by the authority of the national government was crucial – for example, at national level the NDMA is expected to rely on KMD forecasts to inform and justify its decisions. On the other hand, several interviewees mentioned the recent experience of a 'blown' El Niño forecast (resources were mobilised on the basis of predicted flooding, which did not materialise as expected), and the reputational impact this had on the information providers and decision-makers. This case illustrated the importance of the source of information. The El Niño agenda was promoted by NGOs and INGOs, based on information from international sources relying only on El Niño as a predictor of the seasonal rains. KMD did not ascribe to the forecasted floods because the signals from the Indian Ocean were not supportive. In the aftermath, however, it was KMD's

reputation that was hardest hit.

Overall, respondents said that information from the KMD was useful. It was shared in official forums including the County Steering Group meetings. However, only a few people were able to describe in detail how the forecasts were directly put into use. Most water sector stakeholders said that they relied more on the information provided by the NDMA; specifically, their monthly, county-level early warning bulletins, which combine KMD information with data from other sources, and which will be examined in more detail below. The County Ministry of Water, Irrigation and Agriculture receives weather information and forecasts from the KMD, but they also work closely with the NDMA, which is where they get indicator-based cues about the severity and development of drought situations. While the levels communicated in the early warning bulletins initiated meetings, discussions, and further information-gathering, on-the-ground empirical assessments were generally deemed necessary prior to implementing interventions that required mobilising government budgets (for example water trucking, rapid-response repairs, restocking/destocking of livestock, fuel subsidies, and supplementary feeding). These assessments, co-ordinated by the County Steering Group, are commissioned to find the 'real issues' (in the words of an NDMA officer) and to determine empirically the appropriate scale and location of the response, for example which boreholes need repairs, and in which locations trucking might be necessary.[13]

2.5. Negotiating diverse knowledges: boundary objects and hybrid forecasting

As part of the national government's wide-ranging Vision 2030 programme, the NDMA has a strategic goal of 'Ending Drought Emergencies' by 2022.[14] In practice, this means decoupling the physical conditions of drought from their negative socio-economic impacts, so that the 'emergency' level of the early warning system is not triggered. A core role of the NDMA at both national and county levels is to collate different types and sources of knowledge, and translate them into a form that is meaningful and potentially usable by different actors working towards mitigating drought impacts. As such, the NDMA can be described as a 'boundary organisation' (Guston 2001) – a concept from the social sciences literature that describes an organisation that mediates between science and policy.

One of the core 'boundary' activities of the NDMA at national and county level is the production and dissemination of the monthly early warning bulletins. These documents may be characterised as 'boundary objects' (Star and Griesemer 1989), as they provide a focal point around which conversations can be held despite differences in worldviews and disciplines. The bulletins draw on a range of different indicators (biophysical, production, water access, utilization), which are compared to long-term trends and linked to livelihoods impacts and observations about emerging issues including insecurity, conflict and human displacement. In Lodwar, household data is collected by field monitors in 9 'sentinel' sites, during the first 9 days of each month. This primary data is combined with other input, for example rainfall observations, a satellite-based vegetation index, key informant data on market prices, and follow-up assessments if necessary. NDMA officers also consult online sources including FEWSNET, the African Data Dissemination Service, and certain paid-for services (dependent on available budgets). The bulletins also contain future projections for different variables, and an indication of whether the drought status is improving, stable or deteriorating. The latter is based on information including weather forecasts and seasonal climate outlooks from the KMD.

The analysis of the data and production of the Turkana bulletin is undertaken by a working group of NDMA officers. The bulletin classifies the county drought status (normal/green, alert/yellow, alarm/amber, or emergency/red) and includes advice for particular sectors. Once the bulletin is published, if warning levels are triggered – i.e. at 'alert' stage or above - they will be discussed by the County Steering Group, which may then deploy a rapid assessment team. The NDMA officer emphasised that the analysis and decision to issue an alert was undertaken within the NDMA; broader governmental and non-governmental involvement with the rapid assessments was a different stage that would not change the published alert level, but could influence budgeting decisions about how to enact response/mitigation. The care taken by officers to highlight this separation characterises the sensitivity of efforts to maintain the independent scientific credibility of their data analysis while operating in the highly politicised arenas of the identification

and declaration of drought and mobilisation of resources.

Another example of a practical attempt to tackle the challenges of credibly linking knowledge and action was provided by a 'participatory scenario planning' (PSP) workshop, convened by the local NDMA in November 2016 as part of an ongoing effort to bring together the KMD's 'conventional' scientific seasonal forecasts with 'indigenous technical knowledge' (ITK) in the form of forecasts performed by Turkana ritual specialists. Similar workshops have been held twice annually since 2014, when the project was initiated under the auspices of Care International. With the original project now closed, the NDMA must seek other sources of funding to support the events. On this occasion, last-minute funding had been secured from an NGO (Practical Action) and the national government's Agricultural Sector Development Support Programme (ASDSP).

The one-day workshop was held at St Teresa's Pastoral Centre on the outskirts of Lodwar – a popular venue for NGO and government meetings. There were about 40 attendees, from various county government ministries, national agencies, NGOs, universities, and communities. The community participants on this occasion were all from one sub-county, where the NGO co-funder of the event was implementing project work. Following opening remarks from a number of organisations, KMD officers made a formal presentation of their seasonal forecast for the October to December short rains, using PowerPoint slides to announce the expected dates of onset and cessation of the rains, and display the expected rainfall measurements across the county, as compared with historical records. While the organisers noted that it would have been preferable to run the workshop when the forecasts were produced in September, rather than mid-way through the rainy season in question (even if there had been no rains to date), the funding delays had made this impossible.

Next, the agenda called for the presentation of the 'ITK' forecast. The workshop participants moved from the meeting room to the exterior courtyard, where a Turkana *emuron*, or 'seer', (referred to by the convenors during the day as *mzee* – an esteemed elder) proceeded to slaughter a goat and make pronouncements based on his interpretations of its entrails. The emuron had not been in the room during the official presentation of the KMD forecast, on the stated grounds of avoiding charges of influence between the two forecasts.[15] Afterwards, the workshop participants reconvened indoors to compare the two forecasts and explore their potential 'integration' into a 'standardised' scenario. The goal was to work together in groups to produce a list of advisories for different sectors (agriculture, water, livestock, fisheries, etc.) which could be disseminated to Turkana communities across the county.

The convenors described the workshop as an approach to 'downscaling of the forecast to the community level'. Downscaling is conventional technical terminology for using statistical approaches to transform projections generated by global general circulation models (GCMs) into more granular predictions for specific areas; but the usage by the NDMA officers to describe the involvement of traditional divination draws attention beyond a technical concern with spatial scale, to considerations of credibility and relevance for the communities who were being targeted.[16]

Interviews and interactions with NDMA and KMD staff suggested that as individuals, many of them take the wisdom of the Turkana elders very seriously. When questioned about the success of the emuron forecasts, they proclaimed, 'they work!'; when the elders forecast something, 'it happens!' When asked to what they attributed this success, they cited the elders' long-standing and situated understanding of their environmental and social landscape; this was often simply articulated as: 'they know!' One NGO worker said that the emuron forecasts were reliable, as God had given them the wisdom to be able to read that information. (He also cautioned that the forecasts were site-specific, and thought that organisations seeking to use such knowledge should consult with more than one elder.) NDMA and KMD staff claimed that the emuron forecasts and KMD predictions usually 'match', though one officer acknowledged the need for care owing to differences in calendar systems. These officers also noted, however, that the elders' forecasts cover a wider range of phenomena than the KMD predictions, for example conflict and disease. One officer said that he was convinced of the seers' power, because they can enact both prediction and mitigation, citing as an example their ability to avert conflicts that have been foreseen. He

was emphatic that he viewed the seers as experts, not quacks. He (and others) also noted that the elders are crucial to communication with the rural population, because the community members trust them (and do not trust the NDMA or other governmental or non-governmental agencies).

This latter point on communication brought to the fore a more instrumental dimension of 'co-production'.[17] NDMA officers were eager to discuss the 'traditional' modes of communication (such as barasas - community meetings – *edonga* dances and oral traditions) that could be used to disseminate drought alerts and warnings. By involving community leaders and members and providing a space for indigenous knowledge, the workshop organisers sought to build credibility for the process of producing and disseminating weather-based advisories; in other words, to win 'buy-in' from the rural communities.

These processes of knowledge negotiation inspire questions about the purpose, value and politics of this 'co-production': how important is the content of the forecast and advice that is produced, in relation to the process of bringing diverse actors together to share knowledge and discuss different types of information? What information is being extracted from whom, and what are the benefits or costs to those ostensible beneficiaries who contribute their knowledge and time? What knowledge is deemed credible and legitimate? As with any such process, the answers to these questions will depend on who is included and excluded, and – for those who are included – the extent to which their input is valued and influential. The workshop highlighted practical, epistemological and political challenges of what we might call 'hybrid forecasting'. The agenda and activities were framed in a language of integration and standardisation, but obstacles to these goals soon became apparent.

From a practical perspective, this particular workshop faced temporal slippages, in that funding delays meant that the season in question was already halfway through by the time the Turkana KMD forecasts were 'formally' presented and advisories developed for dissemination; this limited the potential usefulness of the forecasts and advisories for facilitating preventative actions. It also meant that some KMD forecasts had already been released prior to the workshop, thus potentially disrupting the stated aim of demonstrating independence by ensuring the emuron was not present to hear the conventional forecast. The delay also disturbed the goal of comparability: the KMD forecasts were for October to December, while the emuron's forward-looking divination covered the forthcoming month (or so) from the point it was made in November. (This slippage in the timing of forecast creation arguably provided a rationale for some of the differences between the forecasts.) It became clear during the workshop that not all the parameters of the forecasts were in common. The KMD presented predictions of the dates of onset and cessation of the rains, and quantified ranges for amounts of rain expected in different parts of the county and their relation to long-term averages. The emuron's forecast included expected timings of onset and cessation, but not quantified amounts of rainfall; as expected he also spoke of related impacts such as floods and animal disease, and other issues such as conflict. Unlike the KMD outlook, the emuron's forecast incorporated advice, for example to move away from flood-prone areas. Thus the forecasts differed in content, and also in form and communicative style.[18]

The differences in styles and parameters drew attention to epistemological challenges of translation that had already emerged in the linguistic dimensions of the workshop activities. Most of the plenary speakers made their presentations in a mix of English and Kiswahili.[19] Several times, community members requested discussion or translation in the Turkana language (Ng'aturkana). These code-switches and translations seemed relatively manageable in the structured presentation formats of the first part of the workshop, but become more complicated once the group moved outside into the compound for the ITK forecast. The emuron made his proclamations in Ng'aturkana, and a designated assistant translated into Kiswahili. Members of the audience started to raise their voices to direct questions to the emuron or the translator, or to offer their own translations in English and Kiswahili. The number of voices multiplied, and after a while the workshop convenor asked the emuron to bring things to a close and provided a summary in English and Kiswahili.

An explicit goal of the workshop was to improve the dissemination, monitoring and evaluation of seasonal forecasts, both by improving access to the

KMD forecasts (inviting community members and asking them to pass on the messages discussed at the workshop), and by involving community leaders and specialists in forecasting and designing advisories, thereby potentially increasing the credibility of the information for these intended beneficiaries. The practical and epistemological challenges outlined here, as well as the implicit power relations of the workshop, make this complicated. The emuron's forecasts of various climatic and social phenomena were translated by the convenors into an outlook for 'normal' rains, which was used alongside the KMD outlook for a 'below normal' rainfall scenario as a basis for discussing potential impacts and devising sector-specific advisories. During the discussion of forecast 'integration', some of the community members in attendance became agitated, questioning the focus on what might happen and what people should do in the future when their people were already facing urgent shortages.

The printed brochure that resulted from the workshop included a simple summary based mainly on the KMD outlook, written in English and accompanied by a photograph of the goat entrails, and a list of sectoral advisories which had been edited by the KMD and NDMA and written out in Kiswahili.[20] Dissemination methods were discussed briefly: how best to inform pastoralist and agro-pastoralist communities (many of whom may not be able to read) of the forecasts and advisories? In the weeks following the workshop, NGO, NDMA and KMD officials travelled to different part of the county, explaining the workshops and delivering brochures and verbal advice, and KMD officials together with the emuron featured on a local radio talk show, fielding questions from callers. In line with Akabwai's (1992) suggestion that participative approaches to livelihood interventions should take account of customary institutions for building trust as well as distributing information, one NGO leader wondered whether future versions of the event should be conducted 'outside' – that is, in the rural Turkana settlements- rather than the NGO/government territory of the pastoral centre in town.[21]

3. Conclusions

In the small but growing town of Lodwar, the challenges of rapid urban growth twinned with institutional complexity in the face of conflicting interests are exacerbated by lack of reliable water infrastructure and inadequate instrumentation and data. Failures in the existing water service place major burdens on the poor – both those who lose access to piped supply and those beyond the supply area whose alternative water sources are put under additional pressure due to the increased demand, resulting in shortages, queues and/or increased prices. Weather and climate information – together with other relevant knowledge - is being embedded in drought management programmes, and for most actors in the water sector this 'translated' version - rather than direct reference to the forecast itself - is used to inform decisions. The relevance of weather and climate information from beyond county boundaries – even from neighbouring countries – must be acknowledged in order to better understand how environmental factors further afield impact water security in this area where arid conditions are 'normal' and there is significant reliance on groundwater. In this complex institutional environment it is also crucial to consider the institutional, infrastructural and governance factors that are key determinants of water (in) security in Lodwar, and to plan for effectively managing what little water is available. Projects aiming to increase the uptake and effectiveness of forecast information are employing ostensibly participatory efforts at 'hybrid forecasting', incorporating indigenous techniques that include non-climate factors, and raising challenging questions about the practical, epistemological and political dimensions of knowledge co-production in the face of environmental and political uncertainty.

In conversations about resource security and risk, concerns about drought and water scarcity were almost always accompanied by reference to 'insecurity,' in the sense of human conflict. This adds an important dimension to the language of water security being used in the REACH programme, and draws attention to the entanglements of environmental and political uncertainties. Insecurity and conflict have wide-ranging implications relevant to the questions of human wellbeing and poverty that guide the REACH research agenda. Two key elements of perceived risk in Lodwar/Turkana – rains and raids – are notably intertwined in two prominent forms of anticipatory knowledge-making: first, in the emuron's interpretation of goat entrails, which delivers announcements about expected rainfall and

conflicts with other groups; second, in the monthly NDMA bulletin, which reports on insecurity, conflict and displacement as well as environmental drought indicators. The link between resources and conflict is not straightforward, and debates are ongoing in the literature concerning connections and causality. Factors including territoriality, ethnicity, organised crime, changes in pastoralist and political contexts (Greiner 2013), and histories of failed developments and the strength or impoverishment of social networks and trust (Eriksen & Lind 2009) influence patterns of violence and adaptive capacity. There is potential for further strengthening of local reporting and data sharing mechanisms, and the meaningful engagement of a wider group of people and organisations in deliberation and planning activities (see also Appendix 1). Recognition of these diverse factors and narratives – and issues of legitimacy in governance – is necessary to understand the landscape of governance and other social factors that influence use of forecast information for decision-making about water security for the poor.

Footnotes

1. Correspondence to: sophie.haines@insis.ox.ac.uk
2. Kenya Meteorological Department.
3. For more detailed accounts of Kenya's political history including the events following the 2007 elections, see Branch (2011).
4. LAPSSET suffered a setback after Uganda, which was initially to build a joint pipeline with Kenya, opted for the Tanzanian route. Kenya now plans to transport the oil from Turkana partly by road and rail to the port of Lamu.
5. Turkana County Government had a meeting (with NGOs and REACH Kenya) in July 2017 to kick-start the process of reviewing the draft Turkana County Water and Sewerage Services Sector Policy; Turkana County Water and Sewerage Services Bill; Turkana County Water Sector Strategic Plan and Turkana County Water Services Regulations 2017.
6. For more on this topic see e.g. Eriksen & Lind (2009), Greiner (2013), Schilling et al. (2012).
7. The process of calibrating and validating satellite-derived rainfall addresses this issue.
8. Access to information is one of the rights and fundamental freedoms enshrined in the Kenyan Constitution. Every citizen has the right to access information held by the state or any other person. However, the implementation of the letter and the spirit of the constitution is still lacking, perhaps given the nascent nature of the constitution.
9. The water audit and related work being undertaken by the REACH Kenya team will help to clarify these issues.
10. Under normal operations, all water released from the dam passes through the turbines. There is a release channel which is designed to allow flow through the gorge, bypassing the generation plant, in the case of turbine failures.
11. The RTI director has also referred to the modelling system as a 'black box' in a magazine profile (Gachet 2013b).
12. The REACH Kenya research objectives towards addressing the uncertainties of groundwater resources in Turkana County include determining the geometry and hydrogeology of the Napu aquifer, its surface water-groundwater interaction and hydrogeo-chemistry as well as recharge characteristics of the system. This will also involve observation and study of adjacent aquifers to the Napu to ascertain its interconnection with other aquifers in the area. As a result, it will be more accurate in the future to identify where to site a borehole successfully in this aquifer and prior estimation of yields and water quality status will also be possible.
13. Some organisations including the Red Cross Red Crescent Climate Centre and national Red Cross societies are looking into the feasibility and effectiveness of forecast-based actions (Coughlan de Perez et al. 2015).
14. The NDMA is a national government agency, established under the NDMA Act of 2016. It has local operations in 23 arid and semi-arid (ASAL) counties. Its history can be traced to a drought contingency planning project in Turkana in 1985, which was then expanded via a collaboration between the Dutch and the Government of Kenya, and then by the World Bank Emergency Drought Recovery Project (from 1992) and Arid Lands Resource Management Programmes, which closed at the end of 2010.
15. This was a standard feature of PSP workshops over

the years, although on this occasion the delay in holding the workshop may have disrupted this ideal of a 'blind test', as the season had already begun and KMD forecasts had been released. However, the KMD officers suspected that their conventional modes of dissemination including via FM radio were not effective in reaching the rural communities (hence the need for the workshops).

16. See also an ICPAC project involving UoN and KMD meteorologists and Nganyi rainmakers in western Kenya (Ouma et al. 2015).

17. The English term 'co-production' was used in the workshop, in the context of both English and Kiswahili speech.

18. See Abbink (1993) for a discussion of the communication style of goat entrail reading in nearby Ethiopia; and Broch-Due (2000) for a description of how Turkana seers interpret the landscape in goat entrails.

19. Many thanks to Bonface Wanguba for assistance with translations from Kiswahili.

20. We do not consider here the question of whether or not the different forecasts were proven 'correct' (or otherwise). Instead, our focus is on the aims, challenges and opportunities of the process of 'co-producing' integrated or hybrid forecasts.

21. We were not able to attend a divination in one of the Turkana communities to compare the context, for example the audience interaction and roles of different people and groups in performing and structuring the process. Some fellow workshop participants with more experience questioned the influence of factors such as the audience questioning, filming, translation and choice/source of goat.

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Appendix 1

'Mud map' of select water sector stakeholders in the Lodwar observatory (including linkages to national government)

The schematic map on the following page (Figure A1) sets out key stakeholder organisations in the Turkana observatory, and shows our interpretation of their relationships in terms of formal reporting lines and information flows, as determined during interviews and documentary analysis. As water functions are not fully devolved, the map shows linkages to national government bodies, as well as county government, civil society organisations, communities and companies. The focus here, as in the working paper as a whole, is on the more ostensibly 'formal' institutions; we recognise of course that the community/public are of crucial importance as key stakeholders and intended beneficiaries of REACH's work in this observatory and the wider programme.

While the map is not exhaustive, and does not show how functions and prominence may shift depending on seasonal/electoral cycles or the occurrence of climate shocks, it nonetheless serves to illustrate the complexity of institutional relationships in the sector. It highlights some of the key 'themes' in which stakeholders have interests (e.g.: drought management; irrigation; biodiversity, water quality and forests; fisheries; rural supply; (peri-)urban supply; WASH; oil; hydropower), and some of the mechanisms of communication and governance deployed in the sector (e.g.: co-chairing of forums; service contracts; MOUs; social licence to operate).

As noted by research participants, there are many civil society organisations operating in this domain – mainly in relation to rural supply/WASH – and both national and county government agencies and ministries have regulatory and operational roles. National agencies such as WRMA, NEMA and WASREB have key regulatory roles (with WRMA prominent for this sector), as indicated by the numerous red reporting lines in the lower right corner; other national bodies including the KMD, NDMA and research institutes are important sources of information for county government, community and civil society organisations, as suggested by the high numbers of blue arrows emanating from the bodies in the top right. The NDMA emerges as a key convenor and translator of information, as evidenced by the density of information flows both in and out of the agency. The role of indigenous forecasters as an information source not only for rural communities but also for other organisations and activities draws attention to the diversity of knowledge types and sources that play a part in the sector.

Many participants articulated concerns about duplication of efforts and information gaps, and noted efforts to overcome these problems, including the establishment of joint forums and events (such as the County Steering Group, WESCOORD, Turkwel Stakeholder Forum, and Participatory Scenario Planning workshops), which provide sites for co-ordination and information sharing. In line with interview comments, a stronger role for WESCOORD could mean that more reporting flows (e.g. from civil society groups and companies) are directed into county-level decision-making and governance. Stakeholders in oil and hydropower sectors appear to focus mainly on regulatory compliance, often relating to national-level requirements; however, as important stakeholders in the water sector in Turkana there is potential for them to engage further with local multi-stakeholder forums and initiatives including WESCOORD and Participatory Scenario Planning activities. Groups such as the recently established Turkwel Stakeholder Forum recognise the inter-county scope of catchment-wide issues in the sector.

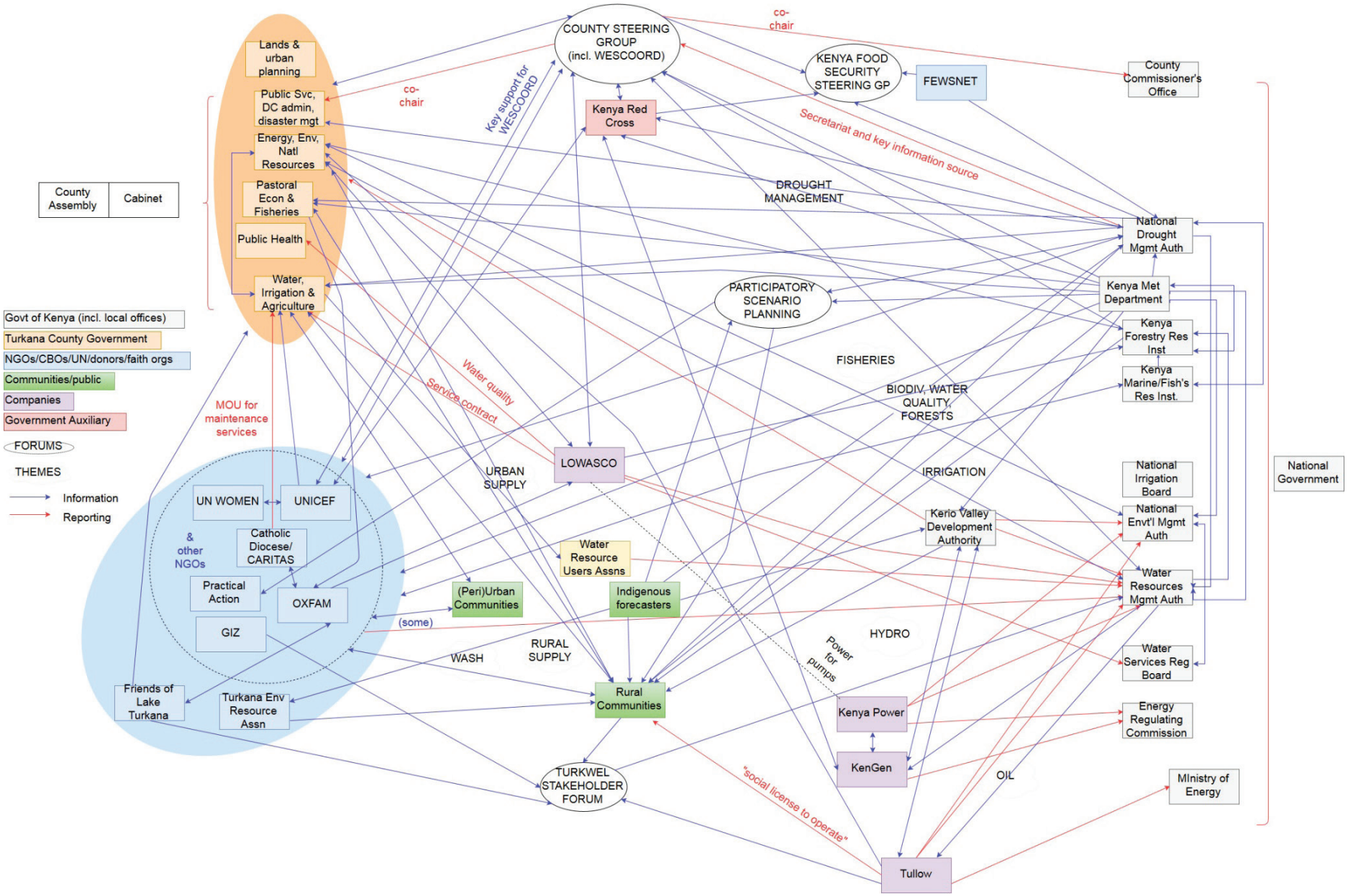

Figure A1: 'Mud map' of select water sector stakeholders in the Lodwar observatory (including linkages to national government)

REACH

Improving water security for the poor

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